MAKING AMMUNITION:
KEEPING YOURSELF SUPPLIED

Authored By Joseph Reichert
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INTRODUCTION

Securing a supply of ammunition is a matter of current concern, because most shooters have experienced some form of ammunition shortage in recent years. In some cases, this shortage was attributable to a lack of reloading tools and materials, in other cases a dearth of surplus military ammunition which had once been plentiful. The circumstances that qualify as an ammunition shortage are too numerous for an exhaustive list, but we all know that we cannot count on an unlimited commercially manufactured supply.

What Is Self Sufficiency?

In this article, I will establish the basic abilities which one must possess to be self sufficient in ammunition; that is, I will explain what an individual must be able to fabricate in order to keep a constant supply of ammunition on hand, suitable for use in the firearms he or she possesses,

without the assistance of any tools or materials supplied by commercial manufacturers. One who has achieved this level of ability may rightly claim to be "self sufficient in ammunition."

This is one aspect of self-sufficiency, which we might call *individual self-sufficiency*. However, from the standpoint of efficiency, economy, and product quality, it may not be beneficial for one person alone to try to cultivate universal knowledge of ammunition making. Such an ability would serve a person who lives in isolation, but such people are few and far between.

In almost all cases, an aspiring ammunition maker will be able to assemble a community of interested students, and cultivate sources of supply in which the different streams they create converge to produce a uniform and reliable product. A completed round of modern ammunition represents the meeting of multiple specialties, and because it seems natural for craftsmen to specialize, I am not exhorting my readers to pursue every single technical process delineated in this essay. In providing a list of all the skills and all the components that go into manufacturing a load, I anticipate that each element of the manufacturing process will likely be mastered by individuals who are particularly drawn to that specialty. In many cases, their pursuit of a particular element of ammunition making may be most heavily influenced by their training and experience, not to mention the tools they already own. With this understanding, let us consider the skills we need to keep our guns shooting.

PROPELLANTS

Before there was anything else, there were propellants, usually in the form of powdered or granulated solids. Most historical studies of firearms development maintain that mixtures similar to black gunpowder evolved long before anything resembling a gun was invented. These mixtures, characterized by the inclusion of oxidizing agents in the recipe, were capable of combustion in closed containers without access to air. The authors of these historical works are mostly of the opinion that these mixtures were first employed as incendiaries, until creative minds thought that they might be capable of pushing projectiles out of a tube with great force. It would not be amiss to say that gunpowder invented the gun.

A mechanism was eventually devised which could accomplish this function, and right thinking men were appalled that illiterate agrarians could cut down the flower of chivalry without engaging in personal combat. Because every tragedy requires a villain, the development of gunpowder for warlike purposes was blamed on the (probably fictitious) Berthold Schwarz.

Black Powder

After a period of development spanning several centuries, the substance we now call black powder became the propellant of choice. By the middle of the 18th century, the formulas for black powder had converged towards the ratios of potassium nitrate, charcoal and sulfur which we now consider optimum for ballistic purposes: 75 parts of potassium nitrate, 15 part of charcoal, and 10 parts of sulfur.

The process for making quality black powder is dependent upon far more than this simple recipe. Even a cursory inquiry into black powder manufacture will reveal that the purity of the ingredients is of great importance, and the provenance of the charcoal is very significant. To obtain a satisfactory result, the charcoal must be made in a closed retort, from the wood of a suitable species of tree, and heated for a specific period of time at a determined temperature. Thorough incorporation of the ingredients is of consummate importance, as well as processes to increase the density of the powder and break it into consistent grains. These are just a few of the techniques which must be brought to bear if we wish to manufacture black powder which will meet the demands of modern shooters.

Once you have black powder, and suitably formed projectiles made from a compliant material, you have all that is necessary to feed a flintlock weapon. You have arrived at the late 18th century in your ability to manufacture ammunition, and you are "self-sufficient in ammunition" provided that you or someone close to you knows how to chip flint. A correctly formed flint, and fine powder dust placed in the pan, comprise the "primer" of your load, and if you are content to stay at this stage of weapons development you need not worry about cartridge casings, nor any other appurtenances of modern ammunition.

I have mentioned black powder which will meet the demands of modern shooters, but this is probably more than is really necessary to render a flintlock weapon useful. During the era when flintlocks were the current technology, it is doubtful that many powder makers sold a product equal to the black powder now available to us. Perusing descriptions of the powder mills established for the Continental Army during the time of the American Revolution, one doubts that the powder coming out of those establishments was uniform in quality. It may not have been up to present day standards, but it sufficed to destroy the power of Great Britain.

But if we are determined to work out a process to manufacture black powder, we have no reason to make anything except the very best. A powder of optimum quality will doubtless give excellent results in both flintlocks and cartridge guns.

Curiously, very little recent literature is available concerning the manufacture of black powder. Little on this topic has been produced for the shooting community, and the researcher is best served by turning to books and articles written for professional pyrotechnists. I intend to cover the pyrotechnic literature in detail in a future article, where I will describe specific techniques necessary to make high quality black powder.

Smokeless Powder

The manufacture of functional smokeless powders is a different matter. It is certainly no safer than making black powder, and distinctly more dangerous if our smokeless powder includes nitroglycerin as one of its ingredients. Personally, I have no interest in attempting to make even small batches of nitroglycerin. I am discouraged from doing so when I consider the number of early inventors and experimenters who were killed when they undertook the task.

There have been several successful powders based upon nitrocellulose alone, and this is a process which can be undertaken by placing well washed cotton in a chilled nitrating solution. When the cotton has been converted to nitrocellulose, it is easily dissolved in acetone, ether, certain alcohols, and mixtures of these solvents. In this gelatinous state, it can be molded and

extruded into selected shapes. I have seen these procedures performed experimentally, and have been advised by the participants that this is not a particularly perilous process. I am not completely convinced by their representations. I have observed some very untoward events in the midst of their operations.

In one particular instance, where the nitration of cellulose was being conducted outdoors on an open table, the whole mass in the nitrating vessel began to bubble, let out long plumes of reddish gas, and suddenly projected a jet of fiercely acidic material over the whole area. By the time the eruption occurred, I had long since left for a location about 25 yards away, and later observed that a good deal of laboratory equipment and a number of record books had been splashed with a mixture of nitric and sulfuric acids. Needless to say, these items were not improved.

Another important consideration about the manufacture of nitrocellulose, is that it is difficult to control the percentage of raw material that ends up nitrated. The percentage of nitration will make a tremendous difference in the potency of the resulting propellant. Firing a cartridge loaded with a propellant of unknown strength is one of the most dangerous operations one can undertake, and is another adventure that I am unwilling to try.

Ammonpulver

There at least one other alternative propellant, and that is the mixture referred to as Ammonpulver. In its most basic form, this is a combination of 80% ammonium nitrate and 20% charcoal, as measured by weight. A variant of this product, called Amidpulver, replaces a portion of the ammonium nitrate with potassium nitrate. I have made no tests comparing these two substances, but I would guess that Amidpulver is easier to ignite.

Ammonpulver and its variants have been used for military purposes, principally by Austria and Germany during World War I. It was employed, with some success, in both small arms and artillery. It was found to have several drawbacks, the most serious among them being the propensity of ammonium nitrate to fracture as the temperature rises. Ammonium nitrate is also prone to absorb water, and has a tendency to erode the metal cases of cartridges. From what I have been able to discover, cartridges based upon it functioned well if used soon after they were manufactured, but became less reliable with time. When Ammonpulver broke down under the influence of heat, the resulting smaller grains produced pressures greater than those considered desirable. Worst of all, these pressures could rise to a level sufficient to damage the weapons in which Ammonpulver was fired.

The problem of water absorption might be corrected by properly sealing cartridges loaded with Ammonpulver. The corrosion of metal cartridge cases could be prevented by coating the interior of the cases with chemically resistant substances. (I believe I have read that the Austrians adopted the expedient of coating the inside of metal cartridges with asphalt.) However, I have found no documentation to indicate that ammonium nitrate can be protected from phase changes induced by heat. In spite of the fact that several United States patents contain instructions for preparing "phase stabilized" ammonium nitrate, this promising technology does not appear to have resulted in a new, reliable form of Ammonpulver.

Ammonium nitrate propellants are very inexpensive to produce, very safe to handle, and when fired in a cartridge are practically smokeless and flashless. If Ammonpulver could be made reliable, it would likely replace all other modern powders. In fact, it could well be the powder of the future. But as I write this, I cannot help but recall a statement made by a cynical Brazilian politician, who declared that "Brazil is the land of the future and always will be."

BULLETS

The Requirement Of Proper Projectile Geometry

Even if our ambitions extend no further than flintlock technology, we will require quality projectiles for our guns. It is almost self-evident that accuracy will require some means of producing symmetrical bullets. Round balls produced for muzzle loading weapons must be truly spherical if the shooter is to have any hope of accuracy. In similar fashion, cylindroconical bullets must be truly symmetrical if the benefits of the rifled bore are to be fully realized; that is, they will require symmetry (cylindricity) along their axis, and it is usually desirable to have a continuous consistent diameter along the entire length of an elongated projectile, unless grease rings are desired, in which case the grooves must be uniform and centered on the axis. These requirements dictate that the molds which form the bullets must be properly dimensioned and symmetrical, that they may correctly replicate the shapes desired.

Tools Needed To Produce Serviceable Bullet Molds

This means that appropriate machine tool technology must be available. Experience shows that the tools used for building bullet molds can be fairly basic. CNC machines, EDM mills and additive manufacturing are not strictly required for this purpose, but conventional lathes and vertical milling machines used in these operations must be repeatable in their functions, and the machinist must have some means of measuring very fine increments of tool movement. Accurate dial indicators are the most basic tools for this purpose, along with such useful items as gage pins and gage blocks.

It is also necessary to consider what type of bullet mold one wants. The reader is probably familiar with the two-part blocks mounted in handles, with a sprue cutoff mounted on the vent into which molten lead is poured. In the United States, the most popular of this type are those sold by Lee and Lyman, but they are also available on custom order from many smaller manufacturers. With this type of mold, the greatest challenge is to ensure that the two halves of the mold come together correctly, so that the plane on which they meet coincides exactly with the central axis of the bullet. It is also vital that the surfaces which come together are completely flat and finely finished, to prevent seepage of molten material out of the mold cavity.

Resizing Of Cast Bullets

A useful refinement in the manufacture of cast bullets is the use of a die to size them and improve their form. The bullet as cast is pressed into the die, or forced through it in a linear motion to reduce its diameter. Such an operation may also serve to improve its symmetry. Sizing requires that the bullet be cast somewhat oversized.

A closely related operation is that of "bumping" a bullet to increase its diameter and shorten it. In practice, the bumping of bullets appears to be more of a hit or miss proposition than forcing them through a reducing die. Bumping can produce unfavorable outcomes, as it may distort a bullets, rendering them lopsided.

There are many complexities in the casting process, corresponding to many differences in the finished product. They are too numerous to explain here, but the composition of the alloy chosen appears to be especially influential in this matter, affecting metal shrinkage, loadability (in muzzle loading weapons), and amenability of the bullets to heat treatment.

Swaged Bullets

There is another technology which frees the bullet maker from the need to melt bullet alloy, and that is the method referred to as *swaging*. In the swaging process, cold bullet alloy is forced into form by extreme pressure, with no heat applied. The practitioners of this technique aver that it is an improvement over the hot casting process, and can do away with the need to resize bullets in dies. In the swaging process, it might be said that all the work is done in the sizing die, the distortions caused by casting being avoided.

Other Methods Of Manufacturing Bullets

As swaging is a form of forging, one ponders if some type of forging process may have been employed in former times, especially to produce bullets made from materials harder than lead. Both written history and archaeological evidence demonstrate that the Mexican army used copper bullets during the 19th century, especially under the leadership of Antonio Lopez De Santa Anna. This makes sense, because Mexico is renowned for its abundant copper deposits, and that metal is dense enough that it might serve in this role. I have not been able to locate any information concerning how these copper bullets were manufactured. If their form were good, they may have been superior to those cast from lead alloy; after all, they came with “copper jackets” built in.

There is also the option of machining bullets, a process which would produce very exact geometry if correctly applied, but would also entail greater expense and waste than any casting, swaging or forging process. Having examined the projectiles used on African dangerous game by British hunters of the late 19th century, I have concluded that some of them may well have been machined rather than cast or swaged. Those I handled appeared to be made of brass, and displayed a very fine geometry and lustrous finish consistent with turning and mechanical polishing. This would be the expensive option, but worth the money if the purchaser anticipates facing an angry water buffalo.

Jacketing Of Bullets

The last consideration I will mention is the covering or "jacketing" of bullets. In recent years I have seen a number of experiments recorded by hard-working amateurs, which prove that they have formed copper and cupronickel jackets. Based upon the photographs and video footage of their efforts, they appear to have been successful in many instances. Needless to say, the individuals working on metal jacket technology have meaningful experience in die

design and the fabrication of metal forming tools. At the present time, I do not possess any printed materials covering the manufacture of jackets, but I am on the lookout for quality information on this topic.

A more accessible technology is the process of paper patching, and there are at least two well researched books available on this topic. In its essence, a paper patch is a paper wrapping placed around a bullet to provide a contact surface between that bullet and the bore. This is a simple technology to implement once a few essential measures have been taken to ensure consistent quality, chief among them being the use of a die to cut out consistently sized patches, the fabrication of a simple guide for wrapping of the paper around the bullet, proper selection of bullet diameter and paper thickness to ensure a satisfactory fit of the finished projectile in the bore, and in certain cases the selection of an appropriate lubricant for the patched bullet.

PERCUSSION CAPS AND PRIMERS

Some History

The percussion cap as a method of ignition was the innovation that ultimately made the modern cartridge possible. The first successful use of an impact sensitive mixture to prime the charge in a gun is usually attributed to the Reverend Alexander Forsyth, the vicar of Belhelvie, Scotland, who found recreation in bird hunting when not ministering to his congregation. The Rev. Forsyth's compound of choice for the primers he invented was fulminate of mercury, a material that I emphatically counsel the reader to avoid at all cost. Whatever the danger to the good minister, his impact sensitive primers proved vastly superior to the flint firing mechanisms which they replaced.

Caps For Muzzleloaders, Primers For Cartridges

At the present time, two basic classes of primers are commercially available: those made for muzzle loading weapons, and those designed to be inserted into cartridges. “Caps” for muzzle loaders are made to fit on anvils ("nipples") which have firing ports drilled in them, the ports communicating with the powder charge and conducting the fire into it.

Primers for cartridges are designed to be pressed into a port in the base of a cartridge, the port likewise having a hole which allows fire to reach the powder. In cartridges manufactured in the United States of America, and foreign made cartridges produced to American standards, the primers have a small metal anvil inserted into them. The priming compound is crushed between the exterior surface of the primer and a small point on the anvil. This style of primer is known as a Boxer primer.

There is a second style of primer, known as the Berdan primer, which lacks its own anvil; the necessary impact surface is built into the cartridge itself, the priming material being hammered between the base of the primer and a nub projecting into the primer pocket.. A cartridge designed for Berdan primers is easily recognized by the small metallic point built into its primer port.

In order to produce any type of primer, the manufacturer must begin with a suitable metal cup. All such cups are pressed from very thin metal sheet, and in the case of caps for muzzle loaders, all I have examined are made from copper or brass. Personnel employed in the commercial manufacture of fixed ammunition inform me that the cups and anvils made for cartridges have, in their experience, always been fabricated from cartridge brass (70/30 brass alloy) rolled into sheets. I do not know if this is still true today, as I write, but I believe they have given me a reliable account of their own observations. It is prudent to assume that materials chosen by the ammunition industry will change, especially if new choices are presented which will make their products safer, more cost-effective, or both.

Requirements For A Successful Primer

The main mechanical requirement for a muzzle loading primer is that it fit the nipple tightly enough that it will not fall off in normal use. Of course, the "normal use" of a muzzle loader weapon may prove to be quite rough. It has always surprised me that the original weapons from the age of black powder did not come equipped with some sort of device to bind the primer to the anvil. Knowledgeable acquaintances have told me that they did not think such a precaution necessary, but I always cite a famous interview given by William Butler Hickok, in which he commented that it was his invariable practice to secure primers to his cap and ball revolvers with melted candle wax, lest they fall off when he needed them most.

A second significant requirement is that the top of the primer make contact with the top of the nipple to which it is applied, and that there be no space between the head of the nipple and the explosive material inside the primer. If a gap is allowed, it may happen that the hammer of the gun will crush the head of the primer and its impact energy will be arrested before the explosive material is pinched between the hammer/primer cup and the anvil. This is not speculation concerning something that might happen, but a memorandum of a problem I experienced when I purchased large musket caps of unknown origin, and used them in a Whitworth rifle. When they went off at all they functioned well, but every fifth cap or so failed to fire, and I found that the defective specimens had crumpled like an accordion. They worked well on a second try, if I pressed them with great force against the nipple, leaving no gap between the priming compound and the face of the anvil.

Dimensional conformity is a more serious requirement when manufacturing primers for use in modern smokeless powder cartridges. In this application, they must be a very secure mechanical fit, and provide a seal which will prevent the leakage of gas out of the cartridge through the primer port. Experts on this topic frequently note that a cartridge primer must fit into the port tightly enough to create a secure gas seal, but not so tightly that it is deformed by the loading machinery when pressed into place. Of course, it is not only the dimension of the primer cup which must be controlled in this case, but the maker must bear in mind that the diameter of the primer port in the cartridge is also crucial. Therefore, the diameter of both the primer port and the primer itself is also important.

Some Primer Compositions More Dangerous Than Others

It is also necessary touch up on the matter of the formula adopted for priming compound. If our objective is efficient small scale production of reliable primers, most makers will be wise to choose the corrosive recipes of former times. Noncorrosive primers are a great boon to

shooters, but mixing noncorrosive priming composition appears to be out of the question if we have any regard for our personal safety.

All noncorrosive primers contain explosive materials such as tetracene, lead styphnate, TNT, and other materials best described as unpredictable. Though the quantities of these substances found in an individual primer are not likely to be fatal, manufacturing them in a mass large enough to make any substantial number of primers may well be. I counsel avoidance of such materials. The United States military used a priming compound called H-48 throughout World War II. This mixture was based upon chlorate and perchlorate salts. While I would not characterize H-48 as a safe alternative, it is as close to danger as I am willing to come. It is my honest belief that anyone who studies the matter with due attention to his own well being will agree with me.

As with all other aspects of ammunition making, *process control* is the key to success. In the case of primers, this means that uniformly blended primer material must be inserted into primer cups of correct size, in the exact quantity required, compressed or somehow tamped down into the base of the cup, fixed in place with some type of binder, and perhaps covered with a very thin paper or foil shield. If we are preparing Boxer primers for American style ammunition, anvils of proper size must also be inserted into the cup to the correct depth. The goal is simple, even if difficult to attain: every primer should function flawlessly, and every primer should be of the same weight, dimensions, and potency as every other primer.

Primer Kits

On the topic of primers, it is important to note that certain expedient systems for primer manufacture have recently been commercialized and offered for sale. Among other offerings, primer composition "kits" are appearing on the market, containing several small plastic bags filled with unidentified chemicals and sold as a unit. The instructions which accompany these kits direct that they be blended by volume, with no special instructions concerning how thoroughly these substances are to be mixed. Having experimented with these products a bit, it is apparent to me that they generally can yield functional primers for muzzle loading weapons, but the manufacturing instructions lack numerous controls, easily implemented, which would yield a much more predictable product.

The most troubling aspect of such a rough and ready system is that chemical compounds provided are unidentified, and this aspect alone raises certain concerns for the safety of those who use it. If I were asked what I think these chemicals might be, I would conjecture that they make up a mixture similar, if not identical to, the old H-48 used in military cartridges. The white powder provided in these kits is almost certainly potassium chlorate or potassium perchlorate. Because a small sack of black dust is included, my hunch is that this material is antimony sulfide. I strongly suspect that sulfur and a bag of binder material (gum arabic or red gum) complete the equation.

It makes perfect sense that the vendors of these kits would not wish to reveal the identity of the materials to the users. Once known, the purchaser will discover that the price charged for the materials is a large multiple of the going market price for these items.

CARTRIDGE CASES

We now approach the holy grail of ammunition manufacture, the production of cartridge cases. Historically, these have usually been manufactured out of 70/30 "cartridge brass" for a host of good reasons. This material has good ductility, is amenable to heat treatment within convenient temperature ranges, and possesses work hardening characteristics which permit manufacturers to confer an appropriate hardness on the heads of their cartridges.

Difficulty Obtaining Reliable Instruction

The precise extrusion of brass cartridges is considered a subject of great expertise and covered by numerous secret processes. At least the term "secret process" gives this technology an aura of romance. Perhaps it would be more accurate to refer to these esoteric manufacturing operations as processes controlled by *tribal knowledge*. *Tribal knowledge* is usually passed on by word of mouth within a manufacturing facility, and if recorded at all will appear in the notebooks which experienced machinists typically store in their tool carts. Upon the death of such a worker, the irritated surviving spouse customarily throws those notebooks away, along with many other books and tools, to make way for a new car.

Machined Cartridge Cases

It may comfort the reader to know that the brass extrusion process is not the only way to produce cartridge cases. Harry Pope, the venerable barrel maker whose fame has never faded, had a great deal to say about machining cases, at least of the simpler straight walled variety. While still working in Massachusetts in the early days of his career, he was a well-known competitive rifle shooter, and declared that he had machined straight walled case for use in his shooting contests. His reason for resorting to this expedient is not apparent to me, but I conjecture that the cost of cases may have had something to do with it. As he was loading and reloading with black powder, his cases had a long life.

I have some experience in the matter of machining cartridge cases. This experience is limited, because I gained it by helping a fellow machinist produce .45 Colt ammunition for his own use, loading it with black powder and firing it in a Peacemaker. I do not know if he ever attempted to load his cases with smokeless powder, and if asked I would have advised him to test such loads in a way that did not put him in danger, preferably in a weapon much less valuable than his beautiful Peacemaker.

I assisted him in producing about 100 rounds on a Hitachi lathe, a CNC machine which used tape feed programming. The process is very straightforward, and we were fortunate to have an extremely accurate and well maintained machine to work with.

The first step in this job was to cut brass rod into slugs, the overall length being equal to that of a finished casing. These were placed in a precision collet equipped with a sturdy stop, so that each slug would enter the collet to the same depth. We then roughed out the interior with a drill, leaving only a little material to be taken off to produce a properly sized cavity.

After roughing the inside of our blanks, my friend completed the full width, depth and bottom profile of the interior with a boring bar he had ground for that purpose. I recall that this boring

process worked, but we had to turn at very low speed to confer the correct profile at the bottom of the bore, and I do not know if his design of the boring bar was less than optimal, or if this was the only result that could be expected given the process we chose. After all was said and done, the casings produced functioned well.

Once we finished work on the interior cavities of the casings, I went to a manual lathe and turned a mandrel which would exactly fit their interior diameter, centered this mandrel on the Hitachi in a four jaw chuck, and mounted the cartridge blanks on it. As each was loaded, it was held in place by a pad in the tailstock, keeping it firmly on the mandrel. A simple turning operation was applied, which approached the cartridge blank from the right hand side, first cutting the profile of the cartridge head (rim and groove) and creating the prescribed wall thickness down the length of the casing. I might add that our mandrel was very carefully indicated in, using a tenths indicator, which was applied at two points on the length of the mandrel, ensuring that it ran true without any wobble (runout).
The last step was to cut a pocket for a properly sized Boxer primer in the base of each case. This was done by removing the tailstock pad, and installing a tailstock chuck and a bit to drill a small centering hole in the head of each casing. The primer port was completed with a simple form tool ground by my friend, which was also driven with the tailstock chuck. During this operation, each case was held on the mandrel by means of a simple round clamp placed near the mouth of the case, causing it to bear tightly on the mandrel.

The entire operation of making these cases, from blank slugs to finished product, took only a bit more than a full morning of work. Part of this is attributable to the fact that my friend did the programming ahead of time, having researched the cartridge dimensions in an SAAMI manual. He also produced his form tools ahead of time, and I was able to turn our simple mandrel while he continued the project on the Hitachi. The time required to make these cases is hardly worthy of imitation by commercial concerns, but when I reflect upon it I am rather surprised at how quickly it went.

These cases, loaded with FFFg, functioned flawlessly in the revolver. It is important to note that I never knew my friend to load the cases he fabricated with anything save black powder. I noticed that various manufacturers of reloading components (Hornady, for example) have prescribed some very powerful loads for the 45 Colt cartridge when used in Ruger and T/C pistols. We never contemplated producing rounds of this power, and certainly never would place such loads in a Peacemaker, even if we had fabricated them "by the book" as prescribed in a reloading manual. One must always be conscious of what weapons can withstand, especially when they are based on older designs.

I might add that we applied no heat treatment to these cases, nor did we make any attempt to work harden the cartridge heads. When I last inquired about the useful life of these cases, my colleague advised me that he had reloaded them more than 15 times when several began to show signs of corrosion. At that point he discarded them, but later repeated this project to replicate other handgun calibers.

I provide this long narrative only to demonstrate that brass extrusion is not the sole process for making cartridge cases. If we go far enough back in firearms history, we will encounter other methods of producing brass cases, though none that we would consider worthy of imitation in modern times. Machining straight walled cases is certainly adequate, under circumstances

where it *must* be adequate. The time invested aside, the biggest problem with this method is the large amount of expensive brass we turned into chips.

The Modern Choice: Extrusion

I am aware of only one modern process for the mass production of metal ammunition cases. This is the well-known, and apparently universally practiced method of extrusion. I have never seen this process explained and illustrated with sufficient detail that it could simply be copied by an uninitiated practitioner. This may be attributable to my ignorance. The large manufacturers must maintain some sort of internal documentation covering their methods, but they are unlikely to release their internal memoranda to the public.

To be entirely accurate, I must state that there are at least two books which appear to cover a great deal of extrusion technology as applied to cartridge casings, and these are works which I intend to reference in my upcoming *Arms And Ammunition Making: A Resource Guide*. I anticipate that this will be ready for release at the end of July, 2025, and it is my intention to offer it free of charge to those who care to download it.

For readers who wish to make extruded metal casings, it may well be best to begin with general works on metal technology, rather than hoping for a complete "how to" on the specific topic of ammunition manufacturing. If they wish to explore this topic as a general branch of manufacturing technology, it would be best to seek out instructional materials which treat the subject of *deep drawing*. Drawing is the process of pressing metal through form tools to create cups, boxes, and similar hollow shapes. In the case of a cylindrical object, such as a brass cartridge case, this process would almost certainly begin with the pressing of a prepared metal disk or round metal plate by actuating a cylindrical forming tool, thereby pushing the round stock into a hollow metal cylinder, such that walls are formed between the cylindrical tool and the walls of the cylinder. In the case of a cartridge, the operation would be referred to as deep drawing.

Deep drawing is generally defined as drawing a cup deeper than one half of its diameter. *Shallow drawing*, on the other hand, is the name applied to the process of drawing a cup to a depth of less than half its diameter. Therefore, we might expect to see shallow drawing operations applied to products like primer cups.

If one wishes to spread his research net wide, it will be profitable to begin an investigation into the topics of mechanical metallurgy and the plastic forming of metals. Many valuable instructional materials on this topic are published by national organizations dedicated to the training of die makers, and some useful information also appears in training manuals for machinists. Considered in its broader aspects, metal forming technology is one of the most pervasive and valuable operations available to manufacturers, and its utility may be observed in many common household items.

A quick perusal of this branch of manufacturing will show that the following problemss must be resolved in order to extrude any metal into a specified shape:

1. The dimension and weight of the blanks selected for elaboration,

2. The initial shape of the blank when it is subjected to the first extrusion operation,
3. The amount of pressure required to produce the desired plastic flow (press tonnage),
4. The number of successive extrusion steps required to bring the walls of a cup or cylindrical vessel to the desired thickness,
5. The dimensions of the tools required to produce that thickness, and
6. In the special case of ammunition, the methods of forming a "case head" and hardening the same.

It is unquestionable that an extrusion process for making cartridge cases can be implemented in a small shop. The main assets required will be dogged persistence and endless patience.

CONCLUSION

It is my sincere hope that this short essay will inspire energetic experimenters to study and implement the manufacturing of ammunition on a small scale, cutting themselves loose from dependence on commercial products and military surplus. Please note that I have nothing at all against commercial ammunition or those who vend it, but it concerns me that the supply can be interrupted through many unpredictable avenues. It would be very advantageous to the shooting community of the United States if intelligent individuals, especially those trained in craftsmanship and science, could be inspired to work out processes for the local manufacturing of ammunition. I will be pleased if my modest efforts can create positive inspiration for such a movement.